Journal of Ethnobiology 22(2): 285–306 Winter 2002

ETHNOICHTHYOLOGY AND FISH CONSERVATION IN THE PIRACICABA RIVER (BRAZIL)

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ABSTRACT.—The impounded portion of the Piracicaba River sustains a recently established small scale fishery. The aims of this work are to verify the knowledge of Piracicaba River fishermen about fish biology and behavior, and to compare this knowledge to scientific information. We interviewed 22 fishermen with questionnaires and photographs of ten fish species. The fishermen showed a detailed knowledge about fish diet, predators, spatial and temporal distributions, reproduction and migratory patterns. Fishermen know better the common and commercially valuable fishes than the rare ones. Important factors influencing local ethnoichthyological knowledge are the value and abundance of the fishes, their usefulness in the fishery, and the frequency with which fishermen observe some of the biological attributes (such as feeding habits) of fishes. Much of the folk knowledge agreed with observations from the scientific literature. Fishermen understand the trophic relationships among native and exotic fish species, and they know the migratory patterns and the habitat preferences of the most valuable fishes. Such folk information may contribute to fishery management strategies. These results show that the folk knowledge held by small scale tropical fishermen is important for improving biological research.

Key words: Ethnobiology, tropical freshwater fishes, fishery, reservoir, freshwater fishermen.

RESUMO.—A região represada do Rio Piracicaba sustenta uma pescaria comercial de pequena escala, estabelecida recentemente. Os objetivos deste trabalho consistem em: verificar o conhecimento que os pescadores do Rio Piracicaba possuem sobre a biologia e comportamento dos peixes e comparar este conhecimento popular com as informações científicas. Foram entrevistados 22 pescadores, através de questionários baseados em fotografias de dez espécies de peixes. Os pescadores entrevistados apresentaram um conhecimento detalhado sobre a dieta, predadores, distribuição espacial e temporal, reprodução e padrões migratórios dos peixes. Os pescadores conhecem melhor os peixes comuns e de valor comercial do que as espécies raras. O valor e a abundância dos peixes, sua utilidade para o pescador, bem como a observação freqüente pelo pescador de atributos biológicos das espécies abundantes, são fatores importantes influenciando o conhecimento etnoictiológico local. Muitas das informações oriundas dos pescadores encontram-se de acordo com observações registradas na literatura científica. Os pescadores conhecem bem as relações alimentares entre espécies de peixes nativas e exóticas, bem como os padrões migratórios e habitats preferenciais dos peixes mais valiosos. Estas informações populares podem contribuir para estratégias de manejo da pesca. Estes resultados demonstram que mesmo pescarias tropicais de pequena escala e estabelecidas recentemente são importantes como um recurso cultural, que deve ser utilizado para guiar e auxiliar na pesquisa biológica.

RÉSUMÉ.—La zone de retenue du fleuve Piracicaba soutient une récente pêcherie de petite échelle. Cette étude a pour but de déterminer la connaissance des pêcheurs du fleuve Piracicaba en matière de biologie et de comportement des poissons et de comparer cette connaissance populaire aux informations scientifiques. Nous avons interviewé 22 pêcheurs en utilisant des questionnaires et les photographies de dix espèces de poissons. Les pêcheurs interrogés ont démontré une connaissance détaillée de l'alimentation des poissons, de leurs prédateurs, de leur répartition géographiques et temporelle, et de leur mode de reproduction et de migration. Les pêcheurs connaissent mieux les poissons ordinaires et les poissons commerciaux que les espèces rares. L'ethnoichtyologie locale dépend essentiellement de la valeur marchande et de l'abondance des poissons, de leur utilité pour les pêcheries, et de la fréquence avec laquelle les pêcheurs observent certains des attributs biologiques des poissons—modes d'alimentation par exemple. Les connaissances populaires correspondent en grande partie aux observations scientifiques. Les pêcheurs comprennent les relations alimentaires entre les espèces indigènes et et les espèces exotiques et ils connaissent les modes de migration et l'habitat préféré des poissons les plus prisés. Les résultats de cette étude montrent que les connaissance populaire dans les pêcheries tropicales de petite échelles peuvent contribuer aux stratégies de gestion des pêcheries et aux progrès de la recherche biologique.

INTRODUCTION

Ethnobiological studies have been furnishing new biological information about insects (Posey 1983), reptiles (Goodman and Hobbs 1994) and fish (Johannes 1981). Such information, if properly interpreted using a biological sciences framework, may be useful to biologists (Johannes 1993). Biological folk knowledge remains little studied, and is being threatened by the disappearance of indigenous people or their customs, as well as by the influence of urbanization and market economy on resource-use strategies (Johannes 1978; Posey 1983; Wester and Yongvanit 1995).

There are two ethnobiological theories dealing with the basis of folk knowledge. The utilitarian view argues that people should know useful organisms with more detail (Hunn 1982). The mentalistic view states that folk knowledge is primarily influenced by factors other than the usefulness of the organisms, such as their abundance in the environment (Berlin 1992).

Ethnoichthyological research provides evidence that both river and marine small-scale fishermen have well established knowledge of fish biology and classification (Begossi and Garavello 1990; Johannes 1981; Paz and Begossi 1996). Comparative studies show that folk knowledge is usually in accord with scientific data (Marques 1991; Poizat and Baran 1997). For example, Pacific island fishermen's information regarding marine fish reproduction helped scientists in the management of fish stocks (Johannes 1981). Northeastern Brazilian fishermen mentioned that the estuarine fish *Arius herzbergii* eats insects (Ephemeroptera) during certain months of the year. This information was investigated and confirmed by fish stomach content analysis, thus revealing a new food chain for tropical estuaries (Marques 1991).

Biological research alone may not be sufficient to gather the amount of data required to manage most tropical nearshore marine fisheries, due to lack of time and money. In such cases, fishery management may be more successfully accomplished if it is also based on contributions from fishermen's knowledge (Johannes 1998). A similar situation occurs in tropical freshwater environments, such as South American rivers, where fishery management suffers from a scarcity of published information on fish biology (Bayley and Petrere 1989; Böhlke et al. 1978; Petrere 1989). In this context, ethnoichthyological studies may be a useful management tool, bringing to light information which may serve both as guidelines for biological research (Marques 1991; Poizat and Baran 1997) and as a quick and inexpensive way to assessing biological data (Chapman 1987; Johannes 1981, 1998).

Southeastern Brazilian rivers and reservoirs drain industrialized regions and have been harvested by fishermen, who typically live in small fishing villages located near urban centers (Castro and Begossi 1995; Silvano and Begossi 1998; Vera et al. 1997). Such villages can be regarded as small "cultural units," subject to a distinctive set of political, economic, social and ecological characteristics. The small scale commercial fishery at the impounded Piracicaba River is of relatively recent origin, as it started around 1962 with the creation of the Barra Bonita Reservoir (Torloni 1994). This fishery has been threatened by environmental modifications such as dam construction, pollution and deforestation (Silvano and Begossi 1998). It is likely that the fishery will decline, with a concomitant loss of folk knowledge; this has already happened in the polluted upper Piracicaba River (Silvano 1997). We believe that such knowledge should be documented, considering its potential usefulness for fish conservation. The main objective of the present study is to document the knowledge of Piracicaba River fishermen about fish biology and behavior. We also intend to investigate the basis for such knowledge, to compare it with ichthyological scientific data, and finally to point out some ethnoichthyological information that may be applied to fishery management.

METHODS

The Piracicaba River in Southeastern Brazil is 115 km long, draining an urbanized region and receiving discharges of industrial effluents and domestic sewage. Barra Bonita Reservoir, created in 1962 with the damming of the lower Piracicaba River, has small fishing villages with active fishermen living along its banks (Silvano 1997). We carried out this study in two of these villages: Tanquã and Ponte de Santa Maria da Serra (Figure 1), inhabited by six and seven fisher families, respectively. These villages are located about 100 km from the city of Piracicaba, São Paulo State, southeastern Brazil. For details about the location of the study sites see Silvano and Begossi (1998). Many houses in both villages belong to tourists, being visited only during weekends and vacations (Silvano 1997).

We interviewed men and women who fish now or had fished in the past. We developed a standardized questionnaire with six questions about fish diet, pred-

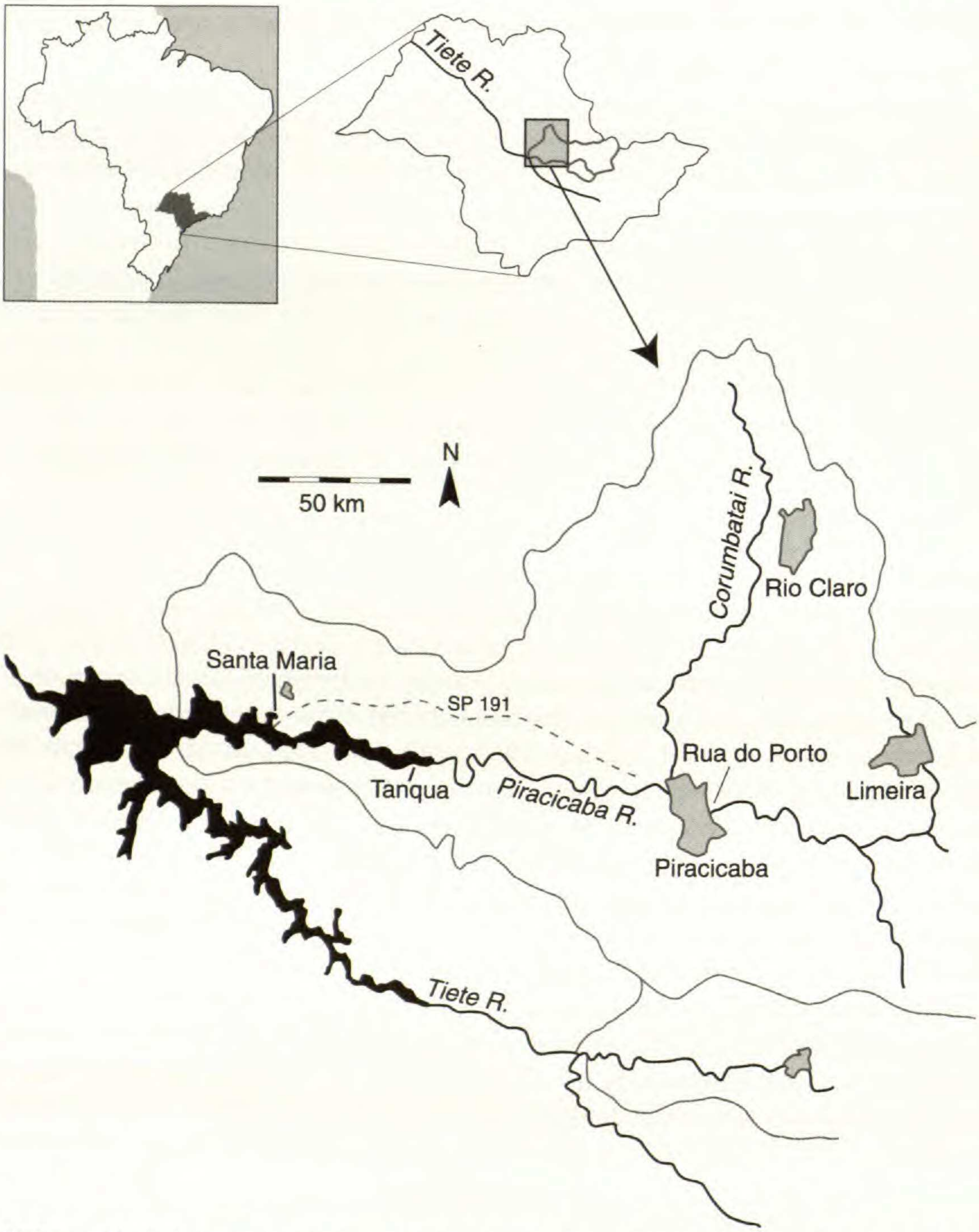

FIGURE 1.—Map of Brazil showing the Piracicaba River basin and the fishing villages of Tanquã and Ponte de Santa Maria da Serra.

ators, seasonal occurrence, habitats, reproduction, and migratory movements. The questions were asked in a manner understandable by the interviewed fishermen, who were allowed to answer in as much time they wanted. For each fish, a color photograph was shown, in the same randomized order for all people interviewed. The questions were:

1) What is the name of this fish?
2) What does this fish eat?
3) Which animals or other fishes prey on this fish?
4) Where does this fish live?

TABLE 1.—Fish species used for interviews, with their abundance and economic value.

Fish species	Family	Common name	n[a]	Abundance % (kg)[b]		Economic value[c]
Astyanax bimaculatus	Characidae	***lambari***	21	10	(679)	medium
Hoplias malabaricus	Erythrinidae	***traíra***	22	5	(363)	medium
Liposarcus aff. *anisitsi*	Loricariidae	***cascudo*** (horn-scaled catfish)	22	11	(801)	medium
Pimelodus maculatus and *P. fur*	Pimelodidae	***mandi*** (catfish)	20	14	(955)	low
Plagioscion squamosissimus	Sciaenidae	***corvina***	21	18	(1289)	medium
Prochilodus lineatus	Prochilodontidae	***corimba***	20	32	(2221)	medium
Rhamdia sp.	Pimelodidae	***bagre*** (catfish)	22	0.1	(5)	low
Salminus maxillosus	Characidae	***dourado***	22	0.8	(53)	high
Steindachnerina insculpta	Curimatidae	***saguiru***	22	0.6	(43)	none
Tilapia rendalli	Cichlidae	***tilápia***	21	0.04	(<5)	low

[a] n = sample size (number of interviewed fishermen).
[b] Values are percent of total fish mass landed in the two fishing villages, during 1994–1995 (Silvano 1997; Silvano and Begossi 1998).
[c] Economic value was assigned to the following categories: none (discarded fish), low (US$ 0.60–0.90 per kg), medium (US$ 0.90–4.40 per kg) and high (more than US$ 4.40 per kg).

TABLE 2.—Comparison of the number of doubts among ten fish species ($\chi^2_{9;\,0.05} = 57; p < 0{,}01$) and six biological attributes ($\chi^2_{5;\,0.50} = 120; p < 0{,}01$).

Fish species	Number of doubts	Biological attributes	Number of doubts
Astyanax bimaculatus	9	diet	23
Hoplias malabaricus	8	habitat	4
Liposarcus aff. *anisitsi*	11	migration	23
Pimelodus spp.	9	predators	4
Plagioscion squamosissimus	8	reproduction	66
Prochilodus lineatus	8	seasonal occurrence	13
Rhamdia sp.	23		
Salminus maxillosus	12		
Steindachnerina insculpta	9		
Tilapia rendalli	36		

5) When is this fish found here?
6) Does this fish move along the river? To where?

Duration of interviews varied, depending on the knowledge and objectivity of the interviewed person. We selected ten fish species for study among the 43 registered in the Piracicaba River fish landings (Silvano 1997). They represent a wide range of fishes that are common and rare, native and exotic, great and small in size, valuable and discarded (Table 1). Comparisons along these gradients should provide some insight into factors influencing the acquisition and maintenance of fishermen's folk knowledge. The number of interviewed people varied slightly for the different fish species because some people could not complete the questionnaire. We compared fishermen's information with data from the scientific literature, following Marques (1991). All fish mentioned in this study were collected and identified for verification.[1] The zoologist Ivan Sazima[2] identified the mammals and reptiles cited as fish predators, which were not collected.

Answers given such as "I do not know" (DNK) were considered uncertain knowledge. Considering that fishermen should best know the fish species or biological aspects with the smallest number of DNK, we compared the number of DNK answers among the fish species and the biological attributes through a chi-square test.

RESULTS

We interviewed 17 men and 5 women, corresponding to about 80% of the resident fishers in the two villages. The common and scientific names, abundance, and economic value of the ten fish species studied are listed in Table 1. Of these, the ***cascudo*** (horn-scaled catfish–*Liposarcus* aff. *anisitsi*, Loricariidae [Figure 2]), the ***corvina*** (*Plagioscion squamosissimus* [Heckel], Sciaenidae [Figure 3]) and the ***tilápia*** (*Tilapia rendalli* [Boulenger], Cichlidae) are exotic to the Piracicaba River basin. Considering the great variety of answers gathered, we show only those mentioned by at least 20% of interviewees.

Factors Influencing Folk Knowledge.—Fishers showed more doubts (less knowledge) about *Tilapia rendalli* and *Rhamdia* sp. ($\chi^2_{9;\,0.05} = 57; p < 0.01$; Table 2), which were

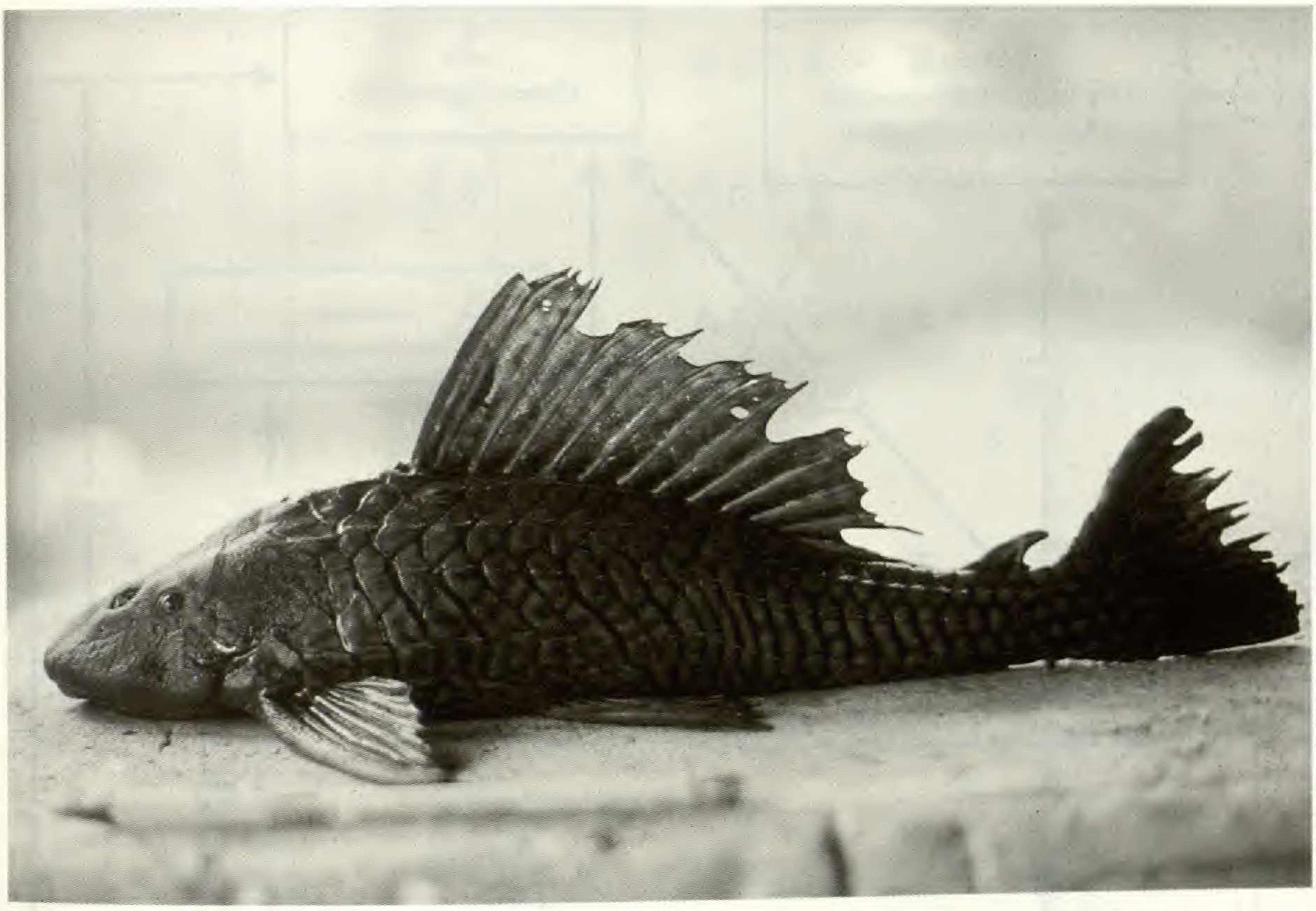

FIGURE 2.—The ***cascudo,*** *Liposarcus* aff. *anisitsi.*

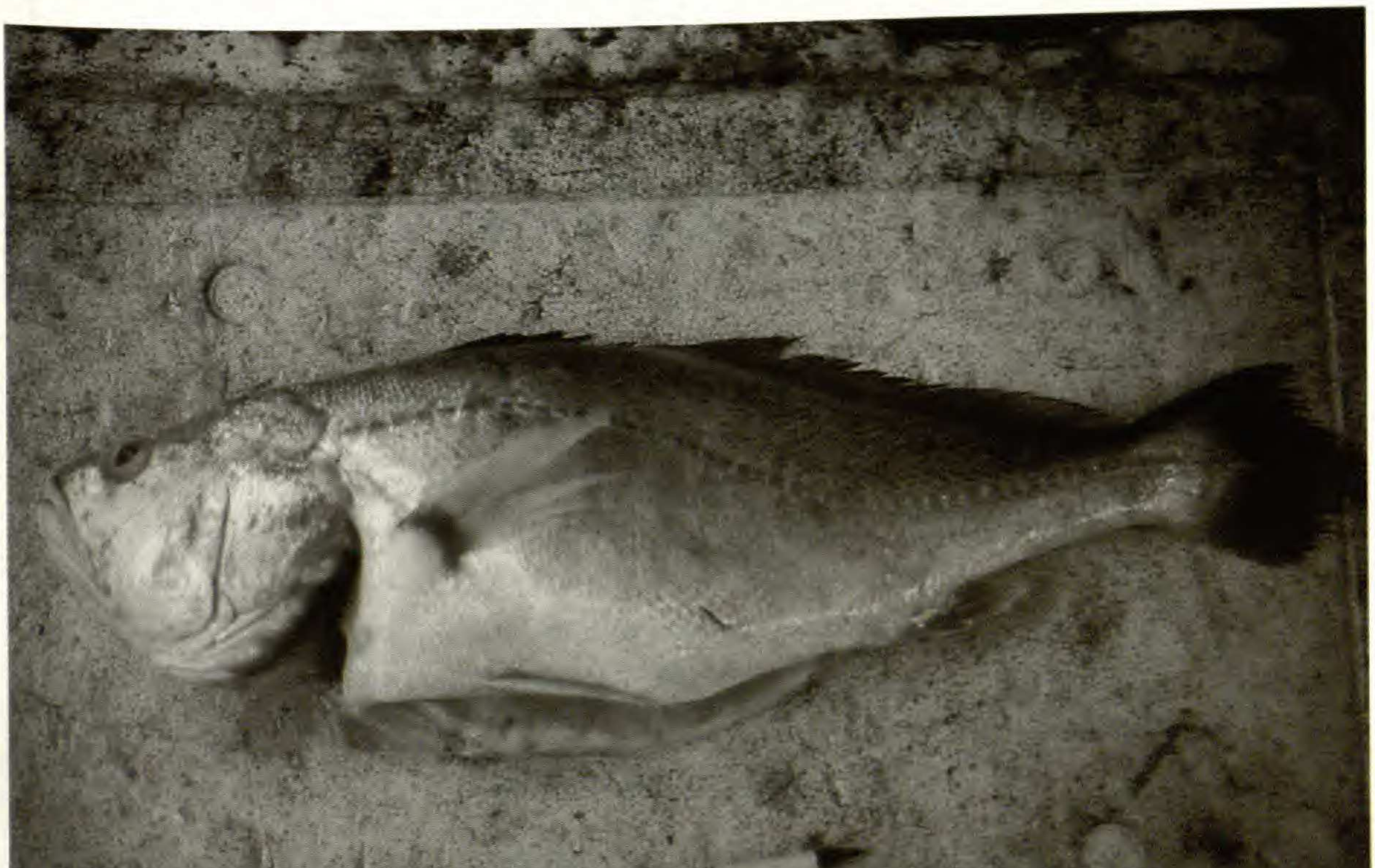

FIGURE 3.—The ***corvina,*** *Plagioscion squamosissimus.*

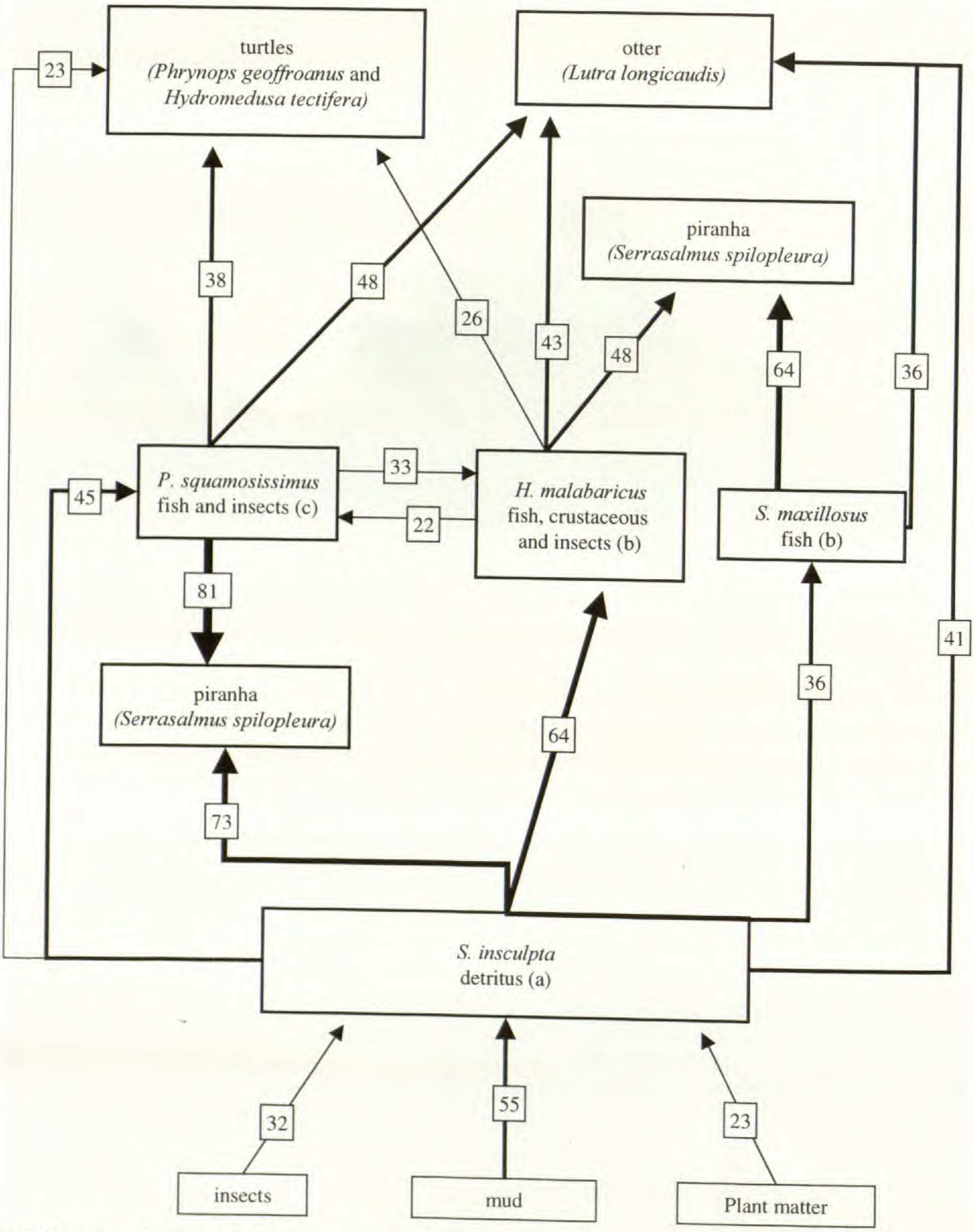

FIGURE 4.—A simplified model of the food web in the Piracicaba River, following fishermen's information about ***saguiru*** diet and predators. Numbers inside small boxes correspond to the percentage of interviewees that mentioned the respective trophic link. Below the scientific names of some of the fish, are fish diets reported in the scientific literature; letters refer to sources: (a) Fugi et al. 1996; (b) Bistoni et al. 1996; (c) Braga 1995.

TABLE 3.—Feeding habits of the Piracicaba River fishes according to the interviewed fishermen.

Food items	Consumers												
	Tilapia rendalli	*Astyanax bimaculatus*	*Steindachnerina insulpta*	*Prochilodus lineatus*	*Liposarcus* aff. *anisitsi*	*Rhamdia* sp.	*Pimelodus* spp.	*Salminus maxillosus*	*Plagioscion squamosissimus*	*Hoplias malabaricus*	Otter	Piranha	Turtles
plant matter	33	29	23	.	.	.	.	.	.	.	.	.	.
mud	48	.	55	85	86	36	65	.	.	.	.	.	.
insects	.	52	32	.	.	.	25	.	.	.	.	.	.
earthworms	.	.	.	.	.	.	40	.	.	.	.	.	.
unspecified fishes	.	.	.	.	.	41	30	.	.	.	.	.	.
Tilapia rendalli	.	.	.	.	.	.	.	.	.	24	29	52	29
Astyanax bimaculatus	.	.	.	.	.	.	.	45	75	80	35	70	35
Steindachnerina insculpta	.	.	.	.	.	.	.	36	45	64	41	73	23
Prochilodus lineatus	.	.	.	.	.	.	.	.	20	.	80	65	35
Liposarcus aff. *anisitsi*	.	.	.	.	.	.	.	.	.	.	22	.	.
Rhamdia sp.	.	.	.	.	.	.	.	.	.	.	48	57	.
Pimelodus spp.	.	.	.	.	.	.	.	.	45	.	70	75	40
Salminus maxillosus	.	.	.	.	.	.	.	.	.	.	36	64	.
Plagioscion squamosissimus	.	.	.	.	.	.	.	.	.	33	48	81	38
Hoplias malabaricus	.	.	.	.	.	.	.	.	22	.	43	48	26

Note: The numbers correspond to the percentage of interviewees who mentioned the respective trophic interaction.

rare and of low economic value (Table 1). Some of the best known fish species are of high economic value, such as the ***traíra*** (*Hoplias malabaricus* [Bloch], Erythrinidae), *Plagioscion squamosissimus*, the ***corimba*** (*Prochilodus lineatus* Steindachner, Prochilodontidae), and the ***lambari*** (*Astyanax bimaculatus* [Linnaeus], Characidae), or are abundant in the fish landings, such as the ***mandi*** (catfish–*Pimelodus* spp., Pimelodidae; Tables 1 and 2). Considering biological aspects, fishermen had more doubts about reproduction than about fish habitats and predators ($\chi^2_{5;\,0.05} = 120$; $p < 0.01$; Table 2).

Comparison of Folk Knowledge with Biological Literature.—A simplified folk food web for the Piracicaba River fishes was constructed, based on fishermen citations regarding fish diets and predators. Each link of the food web, represented by arrows, corresponds to a certain proportion of fishermen's responses during interviews. The width of the arrows reflects the proportion of citations referring to a particular feeding relationship. In Figure 4 and Table 3, the fish diets according to scientific literature (letters referring to the sources) are presented below the fish scientific names. There are four levels in the food web: primary consumers, primary carnivores, secondary carnivores and top predators, allowing the assignment of feeding guilds for the fishes. It was possible to distinguish food specialist (one or two kinds of food) from generalist (three or more kinds of food) fishes. Specialists were piscivorous (*Plagioscion squamosissimus, Hoplias malabaricus*, the ***dourado*** [*Salminus maxillosus*, Valenciennes]) and detritivorous (*Prochilodus lineatus, Liposarcus* aff. *anisitsi*) species. Generalists were omnivorous fishes such as *Pimelodus* spp., the ***bagre*** (a catfish—*Rhamdia* sp., Pimelodidae), and *Astyanax bimaculatus* (Characidae).

Fishermen mentioned about 23 species of fish predators, corresponding to 11 fishes, 5 birds, 4 reptiles and 3 mammals, the most cited being represented in Figure 4. Accordingly with, respectively 35, 26 and 17% of fishermen, ***piranhas*** (*Serrasalmus spilopleura* [Kner], Characidae; Figure 5), otter (*Lutra longicaudis* [Olfers]), and turtles (*Phrynops geoffroanus* [Schweigger] and *Hydromedusa tectifera* [Cope]) usually attack fishes that are entangled in the nets. The ***piranha,*** the most cited predator, preys on all ten fish species studied.

Fishermen mentioned a great diversity of habitats occupied by the fishes, which could be separated into lacustrine (*Hoplias malabaricus, Liposarcus* aff. *anisitsi, Steindachnerina insculpta, Tilapia rendalli*), stream (*Astyanax bimaculatus, Rhamdia* sp.), and river (*Prochilodus lineatus, Salminus maxillosus, Pimelodus* spp.) species, with *A. bimaculatus* and *Plagioscion squamosissimus* being mentioned as habitat generalists (see Table 4).

We observed that fishermen distinguished among migratory and sedentary fish species, and they recognized many kinds of fish migratory movements, from great longitudinal to short lateral migrations (Figure 6). According to fishermen's answers regarding seasonality, *Pimelodus* spp. occur mainly in the winter, *H. malabaricus* and *P. squamosissimus* were common during spring, whereas *P. lineatus* and *S. maxillosus* were most abundant in summer. The seasonal occurrence of the migratory *P. lineatus* and *S. maxillosus* was associated with rainfall (Table 5).

As mentioned in the section above, we had fewer answers about fish reproduction than about other biological characteristics. In spite of this, fishermen did

FIGURE 5.—The ***piranha***, *Serrasalmus spilopleura.*

mention that the majority of Piracicaba River fishes reproduce during summer, which generally agrees with published data (Table 6).

DISCUSSION

Factors Influencing Folk Knowledge.—Our results indicate that the folk knowledge of Piracicaba River fishermen is more detailed for abundant and useful species, especially those that are commercially valued. Similarly, river and maritime Brazilian fishermen classify useful fish with more detail (Begossi and Figueiredo 1995; Begossi and Garavello 1990).

With regard to biological aspects, information about fish reproduction may be difficult for Piracicaba River fishermen to acquire, since fish usually reproduce infrequently in time. Furthermore, knowing when fish lay eggs has no direct usefulness to the fishery. Conversely, information about fish habitat is important for the Piracicaba River fishermen, as a good catch depends on the fishermen's ability to set gillnets in appropriate places. Elsewhere, researchers have shown that knowledge about fish spatial distribution influences river, maritime and estuarine fishing strategies (Chapman 1987; Marques 1991; Petrere 1990). Techniques of attracting wanted fish species by increasing aquatic habitat heterogeneity were documented for fishing communities from the northeastern Brazilian estuary (Marques 1991), African lagoons (Hem and Avit 1994) and India maritime coast (Cruz et al. 1994). Such habitat manipulation does not occur in the Piracicaba River fishery, perhaps due to its recent nature.

Piracicaba fishermen showed a good knowledge about the ***saguiru*** (*Steindach-*

TABLE 4.—Fish habitats accordingly to fishers' answers and scientific literature. Values in parenthesis are percent of fishermen that quoted a particular habitat. (Numbers of fishermen interviewed for each fish species are in Table 1.)

Fish species	Habitat according to fishermen	Habitat recorded in biological literature
Astyanax bimaculatus	stream (38), any habitat (29), main river channel (24), near the shore (24)	wide distribution; streams, temporary pounds, reservoirs, quiet and fast waters, surface and middle water (Uieda 1984; Agostinho et al. 1995)
Hoplias malabaricus	shallow waters (55), lagoon (50), among the vegetation (50), on the bottom's mud (50), near the shore (27)	lagoons, reservoirs, temporary pounds, shallow waters (Resende et al. 1996), among the vegetation, on the bottom (Uieda 1984), near the shore during dry periods (Fink and Fink 1979)
Liposarcus aff. *anisitsi*	rocks (55), lagoon (36), among the vegetation (36)	not found
Pimelodus spp.	main river channel (60), on the bottom (50), shallow waters (20)	main river channel, reservoirs (Agostinho et al. 1995) on the bottom (Barella et al. 1994)
Plagioscion squamosissimus	main river channel (38), on the bottom (29), any place (29), near the shore (24)	wide distribution; quiet water habitats, such as reservoirs and lagoons; among submerged rocks and gravel, open waters, near the shore (Torloni et al. 1993)
Prochilodus lineatus	among submerged logs (60), lagoon (30), main river channel (25)	adults occupy rivers, juveniles occurs in lagoons (Agostinho et al. 1995), feed on the bottom, among the vegetation and submerged logs (Fugi et al. 1996)
Rhamdia sp.	stream (45), main river channel (32), rocks (32)	streams (Agostinho et al. 1995), on the bottom near the shore (Costa 1987)
Salminus maxillosus	main river channel (59), fast waters (45), on the bottom (36), shallow waters (27)	Rivers, fast waters (Agostinho et al. 1995)
Steindachnerina insculpta	lagoon (36), shallow waters (32) near the shore (32), main river channel (27)	Reservoirs, on the bottom and at middle water (Agostinho et al. 1995)
Tilapia rendalli	lagoon (48), among the vegetation (38)	Streams, reservoirs, lakes, (Uieda 1984; Romanini 1989), shoals of juvenile fish in shallow waters near the shore, among the vegetation (Uieda et al. 1989)

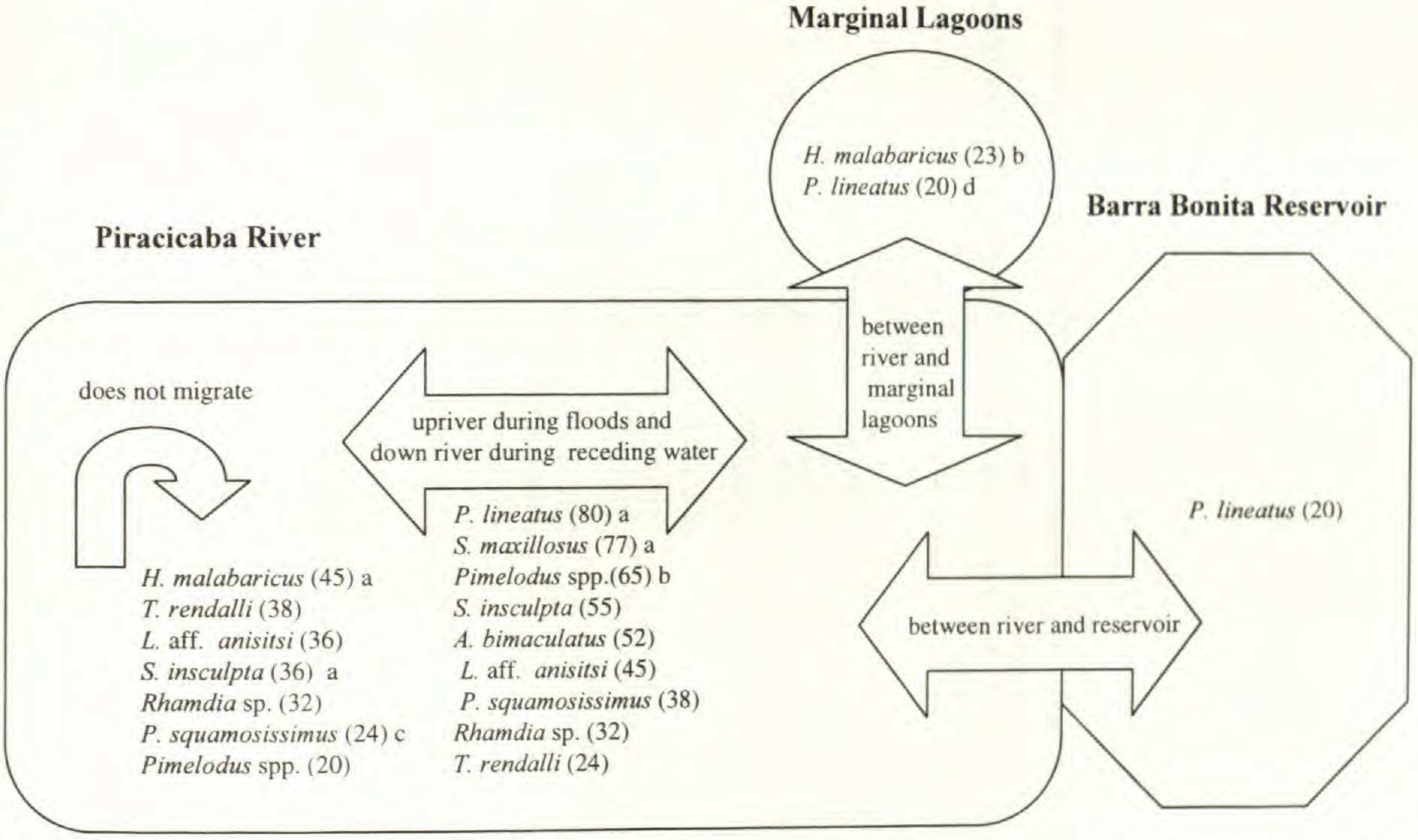

FIGURE 6.—Fish migratory movements according to Piracicaba River fishermen. Numbers in parentheses are the percentages of interviewees that pointed out the movement for the respective fish species. Letters refer to the scientific sources that agree with the information given by the fishermen: (a) Vazzoler and Menezes 1992; (b) Godoy 1975; (c) Petrere 1985; (d) Agostinho et al. 1995.

nerina insculpta; Table 2). This fish has no commercial value and usually is discarded. ***Saguiru*** (fishes from the Curimatidae family, including *S. insculpta*) comprised about 35% of the total catch in the Barra Bonita reservoir fishery during 1985 and 1986, declining afterwards (Silvano and Begossi 1998). This decrease in abundance suggests that ***saguiru*** could have been more abundant or important in the past. Besides this, knowing the habits and behavior of a prey species like *S. insculpta* can help Piracicaba fishermen to find larger piscivorous and valuable fishes, such as *Hoplias malabaricus, Plagioscion squamosissimus* and *Salminus maxillosus.* Amazon fishermen usually track small prey fishes in order to find the wanted piscivorous ones (Goulding 1979).

Fishermen also know in detail fish diets and predators (Table 2), although such information may not be directly useful, as Piracicaba fishermen usually do not use bait. Information about fish feeding relationships may have an indirect value in the fishery, however, as the diet of a fish is usually related to its habitat. Furthermore, fishermen can minimize fish loss from predator attacks if they avoid setting gillnets in places with high predator abundance. Notwithstanding such proposed usefulness, the observed detailed folk knowledge regarding feeding relationships can be also merely due to a high frequency of observation: fishermen frequently clean fish and see stomachs contents, and predators are also commonly observed eating fish entangled in the gillnets. Concerning the conflict of mentalistic versus utilitarian views in ethnobiology, Clément (1995) argued that both utility and observed criteria such as color and morphology could influence folk biological classification, being associated aspects of the same process. Perhaps this

TABLE 5.—Fish seasonal occurrence according with fishers answers and fish landing data (Silvano 1997). Values in parenthesis are the percent of fishermen that quoted a particular season. (Number of fishermen interviewed for each fish species are in Table 1.)

Fish species	Season of greater abundance[a]	
	Fishermen answers	Fishery data
Astyanax bimaculatus	summer (62), spring (43), wet season (29), all the year (29)	summer, autumn, spring
Hoplias malabaricus	spring (73), low water season (32), summer (27), winter (27)	winter, spring
Liposarcus aff. *anisitsi*	wet season (55), all the year (27), spring (27), winter (27), summer (23)	winter, spring
Pimelodus spp.	winter (55), summer (20)	winter
Plagioscion squamosissimus	spring (52), summer (38), winter (33), all the year (29)	autumn, spring
Prochilodus lineatus	spring (70), summer (55), winter (20), wet season (20)	spring, summer
Rhamdia sp.	wet season (36), summer (27), all the year (27), scarce (27)	autumn, winter, spring (scarce)
Salminus maxillosus	summer (45), wet season (32), spring (32), scarce (27)	summer (scarce)
Steindachnerina insculpta	summer (45), all the year (36), spring (27)	discarded
Tilapia rendalli	scarce (48)	winter (scarce)

[a] Seasons are defined as follows: summer (December, January or February), spring (September, October or November), wet season (from November to March), Low water season (from August to November), winter (June, July or August), autumn (March, May or April).

TABLE 6.—Fish reproductive period according to the fishermen answers and from the scientific literature. Values in parentheses are percent of fishermen that quoted a particular season. (Number of fishermen interviewed for each fish species are in Table 1. Seasons are specified in Table 4.)

Fish species	Reproductive period	
	Fishermen answers	Biological literature
Astyanax bimaculatus	summer (64), spring (50)	wet season (Godoy 1975)
Hoplias malabaricus	spring (55), summer (36)	September and October (Barbieri 1989)
Liposarcus aff. *anisitsi*	November (36), summer (32),	not found
Pimelodus spp.	spring (55), summer (45)	not found
Plagioscion squamosissimus	summer (32), all the year (23)	November to February (summer) (Braga 1997)
Prochilodus lineatus	summer (41), spring (41)	spring (November), summer (Agostinho et al. 1995)
Rhamdia sp.	spring (45), summer (32)	spring, summer (Narahara 1983)
Salminus maxillosus	spring (55), summer (50)	spring, summer (Godoy 1975)
Steindachnerina insculpta	summer (59), spring (50)	not found
Tilapia rendalli[a]	summer (18), spring (18)	not found

[a] For this species we present information quoted by fewer than 20% of the interviewees, as the majority of fishermen (59%) know nothing about its reproduction.

conclusion could be also applied to the Piracicaba River fishing villages studied. There, the acquisition of folk knowledge about fish may be associated with the frequency of observation of biological events, whereas diffusion and maintenance of this knowledge possibly depends on its direct usefulness for the fishermen.

Besides exploiting a recent and constantly changing environment, Piracicaba River fishermen exhibited a developed knowledge about fish, even for exotic species, such as *Plagioscion squamosissimus* and *Liposarcus* aff. *anisitsi*. This indicates that folk knowledge has been diffusing in quick and efficient ways among such small fishing villages in southeastern Brazil.

Comparison of Folk Knowledge with Biological Literature.—Piracicaba River fishermen recognized several trophic relationships among fishes. Such relationships form a complex food web, with approximately four levels and several links. Marques (1991, 1995) also recognized complex food webs, with five levels, based on the information provided by estuarine and river fishermen of northeastern Brazil. Tropical river fishes have complex and diverse trophic relationships (Lowe-McConnell 1987). At least some of this complexity is revealed through ethnobiological research, which indicates aspects deserving further investigation. According to the Piracicaba fishermen, detritus is at the basis of the food chain, being the main food for primary consumers and comprising the bulk of the diets of *Prochilodus lineatus* and *Liposarcus* aff. *anisitsi* (Figure 4, Table 3). This agrees with biological studies, which show that detritivorous fish, such as prochilodontids and loricariids, are the basis of many tropical aquatic food webs, being important in nutrient recycling (Bowen 1984; Catella and Petrere 1996; Flecker 1996). Thus we can expect, based on our ethnoichthyological information, that detritus is an essential energy source to Piracicaba River fish and fishery, as observed in other tropical, undisturbed wetlands (Duque et al. 1998).

The predatory fish *Serrasalmus spilopleura* was the main fish predator mentioned by the Piracicaba River fishermen, who said that *S. spilopleura* bites off pieces of fish, preferring caudal fins (according to 17% of interviewees). The proliferation of this fish may be an effect of Piracicaba River damming, as serrasalmids often increase in abundance after a river is dammed (Santos 1995; Sazima and Zamprogno 1985). As mentioned by Piracicaba River fishermen, *S. spilopleura* was observed feeding opportunistically on a variety of other fish species, mutilating the fishes and biting off pieces of the caudal fins (Sazima and Machado 1990; Sazima and Pombal 1988). At the Pantanal Wetlands, the serrasalmids exert a great influence on all fish communities, constraining the behavior and use of space of various fish species (Sazima and Machado 1990). Our results suggest a similar effect of *S. spilopleura* predatory behavior on the Piracicaba River fishes, which inhabited a dammed river.

The otter, *Lutra longicaudis,* was also quoted by most of the Piracicaba River fishermen as a fish predator. Emmons (1990) observed that *L. longicaudis* is an aquatic mammal that feeds predominantly on fish, with diurnal and nocturnal habits, inhabiting clear water and running rivers. Furthermore, this species is currently threatened, mainly by habitat destruction, and its biology and ecology are poorly known (Fonseca et al. 1994). Considering that *L. longicaudis* is usually rare in silt-laden lowland rivers (Emmons 1990), such as the Piracicaba, fishermen's information indicates that populations of this mammal species may still occur in the dammed and polluted Piracicaba River. This information may be useful in reinforcing the need to conserve and restore the ecological integrity of the Piracicaba River Basin, through reduction in water pollution and protection of the riparian forests.

Piracicaba River fishermen associated the seasonal occurrence of large migratory fishes with the rainfall period, thus using climatic clues to predict fish temporal abundance. In fact, an increase in rainfall is one of the factors that releases the reproductive stimulus and migratory behavior of these fishes (Agostinho et al. 1995; Welcomme 1985). Climatic factors, such as winds, floods and tides are essential clues to assess the migratory movements of the fishes that sustain estuarine fisheries in northeastern Brazil (Cordell 1978; Marques 1991) and even for a maritime turtle fishery in Nicaragua (Nietschmann 1972).

Piracicaba River fishermen also mentioned some unknown biological features, such as the timing of reproduction of *Pimelodus* spp. and *Tilapia rendalli,* the migratory movements of *Rhamdia* sp. and *T. rendalli,* and all the biological characteristics of *Liposarcus* aff. *anisitsi.* We also observed some contradictions between fishermen's answers and the biological literature, especially with respect to migratory behavior, an aspect poorly known to biologists. For example, fishermen mentioned *Astyanax bimaculatus* as migratory (Figure 6), although it has been regarded as sedentary (Vazzoler and Menezes 1992). In these cases, biological research could be conducted at the Piracicaba River in order to verify whether fishermen's assertions match scientific observations.

CONCLUSIONS CONCERNING ETHNOICHTHYOLOGY AND FISH CONSERVATION

As discussed previously, information acquired with Piracicaba River fishermen about fish biology is generally supported by the scientific literature, especially regarding fish diet and habitat. Even considering that biologists often deal with the same genus or species from other rivers, the observed concordance between folk and scientific knowledge indicates that folk knowledge probably approaches biological reality, and provides useful support for fishery management decisions. We thus could point out at least three areas where these results would be useful for fish conservation and fishery management actions on the Piracicaba and other rivers: seasonality, effects of exotic fishes, and fish migration and habitat.

Quick Appraisal of Seasonal Fish Occurrence.—Folk information about the seasonal occurrence of fish at the Piracicaba River agreed with fishery data recorded during one year (Table 5). This agreement indicates that an ethnoichthyological survey may be a useful way to monitor fish species abundance when there is not sufficient time or money to gather detailed fishery data or experimental fish samplings. Poizat and Baran (1997) also observed fishermen folk knowledge was consistent with the results of an experimental fishing survey concerning the spatial and temporal distribution of African estuarine fishes.

Estimates of the Effects of Exotic Fishes on Native Fish Fauna.—Invasion or introduction of fish into tropical rivers and reservoirs had been often prejudicial to the native ichthyofauna, which usually suffers the adverse effects of predation and competition from exotic species (Lowe-McConnell 1993; Stiassny 1996). Human induced environmental changes, such as the damming of a river, could favor the proliferation of exotic species (Crivelli 1995). Currently, there is lack of biological studies directed to the interactions with native and non-native fishes for the majority of Brazilian river basins where fish introductions have occurred. The ***corvina*** (*Plagioscion squamosissimus*) and the ***cascudo*** (*Liposarcus* aff. *anisitsi*) are exotic to the Piracicaba River basin, originating, respectively, in the Brazilian Amazon and Upper Paraná basins. While the former was intentionally introduced with the purpose of enhancing fishery yields (Torloni 1994), the latter possibly had invaded the Piracicaba River. The abundance of the ***corvina*** and the ***cascudo*** in the fish catches on the Piracicaba River increased respectively after 1986 and 1993 (Silvano and Begossi 1998). The dissemination of these exotic taxa probably had been affecting the native fish community, yet we do not exactly know the nature and extent of those effects. Although *P. squamosissimus* was studied by Braga (1995), the biology of *L.* aff. *anisitsi* remains unknown. In the present study we provided folk information about the biology of these two species. We believe that such information, if properly interpreted and checked with scientific findings, could help in the understanding of the interactions between exotic and native fish species in the Piracicaba River basin.

According to the majority of fishermen interviewed, detritus is a main food source for the exotic *Liposarcus* aff. *anisitsi* and the native ***corimbata*** (*Prochilodus lineatus*), suggesting that these two species may have been competing for food. This information should be tested through biological studies, considering the importance of the ***corimbata*** to the Piracicaba River fishery (Silvano 1997).

Small characiform fishes, such as *Astyanax bimaculatus* and *Steindachnerina insculpta,* were mentioned by Piracicaba fishermen as important prey species for piscivorous fish, including the introduced Amazonian fish, *Plagioscion squamosissimus* (Figure 4). Braga (1995) conducted a study of the *P. squamosissimus* diet through stomach contents analysis, observing that *A. bimaculatus* was one of its main food items. This feeding interaction was also mentioned by 75% of the Piracicaba River fishermen interviewed. Furthermore, respectively 80% and 45% of fishermen mentioned *A. bimaculatus* as food for *Hoplias malabaricus* and *Salminus maxillosus,* two native Piracicaba River piscivorous fishes (Table 3). This study thus indicates that the introduction of *P. squamosissimus* may have been adversely affecting the native Piracicaba River fish community, both through predation pressure on the *A. bimaculatus* population and competition for food with *H. malabaricus* and *S. maxillosus.* In other tropical freshwater habitats, such as the African lakes, the introduction of predatory fish species severely disrupted the fisheries and caused the extinction of many native fish species (Lowe-McConnell 1993).

Information about Fish Habitats and Migratory Behavior.—Piracicaba fishermen furnished information about fish habitat preferences and migratory routes. A considerable amount of effort is necessary to assess this kind of data through biological research. Piracicaba River fishermen mentioned that the aquatic vegetation is a habitat for *Hoplias malabaricus*, *Liposarcus* aff. *anisitsi* and *Tilapia rendalli* (Table 4), plus *Plagioscion squamosissimus* (19%), *Prochilodus lineatus* (15%) and *Steindachnerina insculpta* (18%). The aquatic vegetation is an important refuge and feeding ground for freshwater fishes (Junk et al. 1983; Lowe-McConnell 1987; Sazima and Zamprogno 1985), which reinforces the need for biological studies directed at corroborating or refuting the suggested importance of riparian and submerged vegetation for the Piracicaba River fishes.

There is need for detailed studies of fish migration in the Piracicaba and in other Brazilian rivers. Our results may help in filling this gap, as Piracicaba fishermen mentioned nine fish species as migrating up and down the river, especially *Prochilodus lineatus* and *Salminus maxillosus*; *P. lineatus* also moves between the river and marginal lagoons (Figure 6). Both these species must migrate in order to reproduce (Vazzoler and Menezes 1992), and juveniles of *P. lineatus* grow in marginal lagoons, moving to the river when adults (Agostinho et al. 1995). Fishermen's answers indicate that *P. lineatus* and *S. maxillosus* may be undergoing migrations in the Piracicaba River, in spite of the dam downstream. This hypothesis should be verified through migratory studies, in order to support management measures directed to ensure the continuity of the migrations and the reproduction of these two commercially important fish species.

Our study demonstrates that ethnoichthyological knowledge is not only restricted to indigenous fishing people, which harvest the same region over the course of centuries or millennia. Small-scale commercial fishermen also show a detailed folk knowledge, even over the course of a few generations. Tropical artisanal fisheries have been widely subjected to external influences, such as habitat degradation and market pressure, which have threatened not only the fish stocks, but also the fishing communities. It is an imperative task to document and interpret fishermen's folk knowledge, especially in the tropics, for it could enable scientists to work together with fishermen in devising measures aimed at conserving both the fish and fishing culture.

NOTES

Erratum. In this article, the term "fishermen" designates both the men and the women interviewed in the Piracicaba River fishing communities.

[1] Voucher specimens are deposited at the fish collection of the Museu de Zoologia da Universidade de São Paulo (MZUSP), CP 42694, 04299-970, São Paulo (SP), Brazil. Only *Salminus maxillosus* was not collected; it was identified with color photographs.

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ACKNOWLEDGMENTS

Thanks are given to the fishermen from Ponte de Santa Maria da Serra and Tanquã for their friendship and kindly collaboration for this work, to L. Sanchez, who introduced R.A.M.S. to the fishers; to O. T. Oyakawa, for help with fish species identifications, to I. Sazima, for help with fish species identifications and valuable suggestions, to M. Petrere

Jr. and M. M. Habib for valuable suggestions; to CAPES and FMB for scholarships to R.A.M.S., to CNPQ for a research productivity scholarship to A.B., and to FAPESP and PADCT-Finep for financial support of the fieldwork.

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